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Fluid Dynamics of Particle Formation

DANIEL D. JOSEPH

Regents Professor
IT Aeorspace & Engineering
University of Minnesota
mailto: joseph@aem.umn.edu

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We have developed a numerical package to simulate particle motions in fluid interfaces. The particles are moved in a direct simulation respecting the fundamental equations of motion of fluids and solid particles without the use of models. The fluid-particle motion is resolved by the method of distributed Lagrange multipliers and the interface is moved by the method of level sets. The present work fills a gap since there are no other theoretical methods available to describe the nonlinear fluid dynamics of capillary attraction.

Two different cases of constrained motions of floating particles are studied here. In the first case, we study motions of floating spheres under the constraint that the contact angle is fixed by the Young-Dupre law; the contact line must move when the contact angle is fixed. In the second case, we study motion of disks (short cylinders) with flat ends in which the contact line is pinned at the sharp edge of the disk; the contact angle must change when the disks move and this angle can change within the limits specified by Gibbs extension to the Young-Dupre law. The fact that sharp edged particles cling to interfaces independent of particle wettability is under appreciated and needs study.

The numerical scheme presented here is at present the only one which can move floating particles in direct simulation. We simulate the evolution of single heavier-than-liquid spheres and disks to their equilibrium depth and the evolution to clusters of two and fours spheres and two disks under lateral forces collectively called capillary attraction. New experiments by Wang, Bai and Joseph (WBJ 2003) on the equilibrium depth of floating disks pinned at the edge are presented and compared with analysis and simulations.

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